

Financial Services

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EXECUTIVE SUMMARY

Within financial services, the property insurance industry is most likely to be directly affected by climate change, since it is already vulnerable to variability in extreme weather events. The cost of weather-related disasters to insurers has risen rapidly since 1960. For example, the annual insured cost of major windstorms worldwide increased progressively from \$0.5 billion in the 1960s to more than \$11 billion (constant 1990 dollars) in the early 1990s. This trend has led to restrictions in coverage or steep price increases. Where insurance is unavailable or unaffordable, there are consequences for other economic activities, as well as for consumers and government. New enterprises may not start without insurance. Banks may be exposed to losses where financial transactions are backed by property.

There are several reasons for the escalation in the cost of severe weather. Developed countries have become wealthier. Many more people now live in coastal areas with costly infrastructures. Personal goods and business processes are generally more vulnerable to water damage. The built environment also contributes through inappropriate or incorrect design and construction. The insurance industry has compounded matters by extending the basis of coverage. It is a common perception in the insurance industry that there is a trend toward an increased frequency and severity of extreme climate events. The meteorological literature fails to substantiate this in the context of long-term change, though there may have been a shift within the limits of natural variability.

There is medium confidence that climate change will adversely affect property insurance. More frequent intensive rain events and sea-level rise are material to both storm and flood damage. The climatological literature does not supply sufficient information about future storms in relation to population centers or “combined events,” like windstorms associated with heavy rain and storm surges. This could critically alter the pattern of insurance claims. Further, the industry is vulnerable to shifts in the variability as well as the scale of extreme events, and this is still obscure. Meteorological records are too short to calculate return periods of extreme events under current or changing climate conditions. The property insurance sector is

very interested in the probability of events two to three years ahead, rather than the timescales associated with climate change. Research on teleconnections where there is a substantial lag between the event and its precursor offers the possibility of improved forward planning for the industry.

Through its experience, the insurance sector can help authorities to improve the response to property damage from extreme events. Control of land use, particularly in floodplains and coastal zones, is essential to prevent values at risk increasing. Information about hazards can be mapped and appropriate physical protections put in place. Necessary improvements to construction design and processes can be identified and incorporated into new building and, if possible, also retrofitted. Many countries now accept that it is not appropriate to account for insurance against extreme events on an annual basis, since funds need to be accumulated over a long period to meet infrequent but severe losses. Where it is not possible to provide private insurance, the industry can still assist with disaster-recovery services. This generally will prove to be a very efficient method compared to other *ad hoc* approaches.

The implications of climate change for financial services outside property insurance cannot be stated with any confidence. Few institutions, if any, were aware of the potential implications when this assessment began. Yet changes in human health may affect the life insurance and pension industries. Banking may be vulnerable to repercussions from property damage. Returns on long-term investments and capital projects may be affected by mitigation measures that alter the economics of whole industries—for example, shifting from carbon fuels to renewable resources. The economics of selected regions, such as coastal zones and islands, may be disadvantaged. Climate change might affect client behavior, or even alter the available portfolio of clients through the changing economics of different industries. Outsiders will be keen to know how the financial sector deploys its funds in the light of climate change. There is a need for increased recognition by the financial sector that climate change is an issue that could affect its future at the national and international level. This could require institutional change.

17.1. Introduction

This chapter commences with a brief overview of financial services. Property insurance is reviewed in more detail as the financial area most vulnerable to direct climatic effects, through multiple claims arising from extreme weather events. The study considers which extreme events are important for property and our limited knowledge of their past and future patterns. Because the future position is unclear, and the previous Assessment Report did not deal extensively with financial services, Section 17.5 discusses the recent upward trend in the cost of extreme events and the criticality of such shocks to the financial system. The techniques property insurers use to adapt to changes in risk also are described, before the chapter looks at how climate change will affect other financial services. Most likely it will be indirectly through the measures taken by other industries or policymakers to adapt to, or mitigate, climate change. Finally, the chapter summarizes cross-cutting implications for policymakers and indicates ways to make future assessments more effective. To the outsider, the discussion may seem biased toward property insurance. This reflects the reality of the direct impacts of climate and the available literature. The indirect impact of climate change outside property insurance is unclear and largely unresearched.

17.2. Financial Services

This section deals with external factors that affect the whole sector. The financial services sector falls into two broad clusters—insurance and banking, which will be described in Sections 17.3 and 17.7, respectively. It has evolved into a highly complex system that recycles “money” among other parts of the economy, including final consumption and capital investment. Governments participate to a varying degree through public debt issues and other investments, and the process operates on timescales from days to decades. The definition used here excludes foreign aid. Clearly, many countries have significant noncash economies; the discussion excludes those activities. Many of the costs of extreme events recorded by the financial sector reflect impacts in other sectors. Although this is in a sense “double-counting,” the financial sector transmits these effects to other sectors and may indeed amplify them if it is unable to fulfill other services through lack of capital.

Projecting the impact of climate change strictly requires a view of future society at the relevant horizon. Given the unforeseen changes over the past 100 years, clearly such an attempt for the next 100 years would be highly inaccurate. The alternative adopted here is to identify current trends that may be relevant, without drawing up a coherent “worldview.” Technological advances are accelerating, particularly in transportation, telecommunications, and information technology. This is leading to the globalization of society (Kennedy, 1993). Systems are becoming more complex and interconnected, with increases in the scale of operation and associated risk (Giarini and Stahel, 1994). Society is increasingly vulnerable to disruption because consumers are living on credit and businesses are

adopting “just in time” techniques. As society becomes more dependent on electricity, any supply disruptions from extreme events become potentially more catastrophic. Economic development has been rapid, bringing with it wealth but also pollution. In many cases, development has occurred in vulnerable locations (see Chapter 12). With the progression from primary to tertiary activities, the impact of climate change on many areas is likely to be indirect and thus more difficult to judge, particularly because social change also has been rapid. Population has burgeoned in many countries, and standards of behavior have altered regarding fundamental issues like the family, crime, and work (Kennedy, 1993). Consumerism and environmentalism have developed strongly as education has spread. Much financial services activity is “driven” by the private automobile, financing its purchase and use. Therefore, mitigating climate change by altering auto use would affect financial services. On the other hand, current trends in auto use cannot continue without putting enormous stress on society (Northcott, 1991). The answer may be to exploit telecommunications as a substitute, but this is not certain.

Trends to deregulate financial services nationally and internationally are putting traditional distribution methods under pressure. Tele-selling will be an increasingly important influence. It is likely that there will be fewer independent operators, often integrated either horizontally or vertically to provide benefits of scale or synergy (Swiss Re, 1992; Muth, 1993). It is possible that clients will key their own information (e.g., through the Internet). Data retrieval will become easier as paper files disappear. Information will become critical for management purposes, not just for recordkeeping. More powerful computers will facilitate the analysis of internal and external databases for sales and underwriting (Dlugolecki, 1995).

Many economies have been plagued by enormous surges in property values, followed by stagnation or even collapse. This makes it difficult to assess assets and liabilities. A second factor that complicates the valuation of property is the generally high rate of inflation between 1960 and 1990. A further difficulty is fluctuating exchange rates in economies with unstable currencies. Such instabilities have led to high interest rates and periods of rapid investment gains. These have diverted attention to “cash flow” strategies (Swiss Re, 1991) and also have created the possibility of insolvency through poor investments (Denlea, 1994). Another area of pressure on financial services is the need to fund environmental claims—seen at its most energetic in the United States, where the Superfund legislation has created huge liabilities for the property-casualty industry (Nutter, 1994). The banking industry also is threatened by “lender liability” as a consequence of repossessing or taking control of polluted land or a polluting operation (Vaughan, 1994).

17.3. The Property Insurance Market

The insurance industry serves to protect other activities from the financial consequences of unexpected events, including natural hazards; therefore, it is directly exposed to climate

change (Friedman, 1989; Roberts, 1990). Since 1987, fifteen extreme weather events have cost property insurers and reinsurers \$50 billion (Leggett, 1994). In view of these impacts, Sections 17.3 through 17.6 consider property insurance and associated “interruption” coverage. “Property” is defined as buildings and their contents, business and personal goods, and plant and infrastructure; conveyances, livestock, crops, and humans are excluded.

The basic function of insurance is to transfer financial risk from an individual to a group; what is a disaster to the individual can often be managed by larger numbers. Typically, the individual proposes his risk to the underwriter, often with the assistance of an intermediary or broker. In some cases, the risk must be evaluated in great detail, and the insurer may stipulate certain actions (risk management) to reduce the likelihood and scope of potential loss. Finally, the insurer offers specific terms in a policy. The most important terms of the contract involve the price, or premium; any exclusions of events or property not covered by the contract; and limitations on the amount to be paid in a claim. Contracts of insurance are usually renewable. Usually the contract lasts for twelve months and is renegotiated with a

view to changes in circumstances, particularly claims experience. Following acceptance of the risk, the insurer must then decide whether to share it with reinsurers. The reinsurer may further spread the risk by “retrocession” to other reinsurers, but this has become less common. The other key activity is settling claims. After a loss, the policyholder reports it to his insurer, who will decide how much investigation is necessary. A loss adjuster is often retained for this purpose. Claims recovery often provides the occasion to implement risk-improvement measures. Policies have become more comprehensive over time, culminating in “all risks” coverage, where the policy stipulates what is excluded. Other significant changes have been to allow for inflation in property values by indexation, and to set aside the effect of depreciation by using replacement values. Finally, policies often allow for economic costs such as alternative accommodation if a claim results in temporary relocation.

17.3.1. Scale of Activities

The scale of the industry is measured either by premiums written or capital available. In 1992, the worldwide non-life insurance

Box 17-1. Examples of Property Insurance and Weather Cover

Property insurance is used to varying extents by different nations. Often, consumers are reluctant to purchase sufficient coverage. Lack of capital, culture, and consumer attitude to risk play their parts. In other cases, insurers are unwilling to provide affordable coverage because of an unduly high ratio of risk to return on capital. Lack of flood coverage is the most common absence of insurance. A selection of schemes for natural disasters is discussed briefly below.

Japan

Windstorm—Full coverage became generally available in 1984, with significant deductibles. In 1991, Typhoon Mireille consumed half of the tax-deductible catastrophe reserves insurers had accumulated (Horichi, 1993).

United Kingdom

Flood and subsidence—Coverage for these perils was added to virtually all domestic building policies in the 1960s and 1970s, respectively, at uniform rates. The market is now moving toward risk-based rating (Dlugolecki *et al.*, 1994).

Netherlands

Flood risk—The government accepts responsibility for physical protection. Insurance against flood is not available.

United States

National Flood Insurance Program (NFIP)—Coverage is not privately available. Communities must qualify for the NFIP by undertaking a risk assessment and reduction program (FEMA, 1992a). Problems often arise with determining whether water damage stems from rain or storm surge (Kunreuther *et al.*, 1993).

France

Natural catastrophe—A 1982 French law attached natural catastrophe to all property policies at a centrally determined set of surcharges on the basic premium. Claims are made only if the authorities declare a disaster. In 1990, the scheme was revised to exclude storm, but many practical problems remain, such as the difficulties of separating storm and flood damage and the issue of uninsured property owners (Florin, 1990).

Caribbean

As a result of heavy hurricane damage in the 1980s and 1990s, many insurers and reinsurers withdrew from the area. Remaining reinsurers insisted on separate, increased rates for windstorm, introduction of the “average” clause to eliminate the effects of underinsurance, and high deductibles for catastrophe losses (Murray, 1993; Saunders, 1993).

industry generated premiums of \$700 billion. The United States accounts for 44% of the total, the European Union (EU) 29% and Japan 12%, leaving the rest of the world with 15% (Swiss Re, 1994b). These sums meet all claims: liability, accidental damage, fire, and natural hazards, as well as administration costs. Figures on capital are not readily available, but a commercial insurer would generally maintain capital at 40–50% of premiums, giving an equivalent of \$280 to \$350 billion. This capital provides a reserve to meet all unexpected costs, not just those from extreme weather events, and it is usually subject to a legal minimum requirement (e.g., 17% of premium in the EU). It is reinforced by reinsurers' capacity, but again the capital is required for various classes of claims. The scale of the commercial non-life reinsurance industry is hard to estimate. Based on estimates by Foreman (1989) for the United States, the net premium volume is probably about \$100 billion, with capital reserves about the same size. Two-thirds of the capital is required to fund non-property business (Laderman, 1993), leaving approximately \$35 billion for natural catastrophes.

17.3.2. *Methods of Risk Assessment*

Natural hazards are dangerous because of the likelihood of an accumulation of loss through damage to many individual properties (Nierhaus, 1986). Underwriters seek to estimate the maximum probable loss. In fact, any level of loss must have a finite chance of being exceeded; Tiedemann (1991) points out that under certain conditions, a 90% probability of being free from an event for 100 years implies that the event occurs once in 1,000 years. Four methods of a risk assessment are described by Friedman (1984): conventional pricing, two-tier pricing, stage-damage, and simulation.

Conventional pricing is experience-based but with a short "memory," giving a dubious allowance for disasters. Two-tier pricing has a first element based on experience, but also a second element specifically for disasters, set notionally. For stage-damage, the property at hazard is characterized by its key dimensions and vulnerability to different levels of event. Detailed knowledge of the local terrain is then used to model the likely impact on the property of a specific event. In simulation, the portfolio of property is treated at an aggregate level, and the likely damage is assessed by evaluating the damage over a large number of extreme events intended to be typical of the long-run distribution of severity and frequency. This approach overcomes two problems: first, that there are not many catastrophe events in practice, and second, that historic damage reflects very different portfolios (Clark, 1986). The third and fourth methods require considerable data. Topography can affect the damage potential by more than 100% (Georgiou, 1989). Other difficulties are that it may not be practical to keep a schedule of property; losses to production may be caused by events elsewhere; and one "event" may strike several "target" locations (Meek and Tattersall, 1989).

Two other methods are event prediction and parallelisms. As scientific knowledge grows about the conditions that produce

hurricanes and other extremes—often months ahead of their occurrence—it is becoming possible to use specific probabilities rather than generalized ones as in simulation (North Atlantic storms: Tinsley, 1988; hurricanes: Clark, 1992; Landsea *et al.*, 1994). In fact, more and more disturbances can be associated with the El Niño Southern Oscillation (ENSO) phenomenon. Alternatively, where data on extremes is lacking, similar conditions may generate a similar distribution of extreme to normal frequency/severity, as for rivers (Meigh *et al.*, 1993).

There now are many applications of Friedman's techniques: storm surge (Stakhiv and Vallianos, 1993), flood (Smith, 1991), and European storms (Schraft *et al.*, 1993). The insurer can study the potential effect of historic events on today's exposure, model hypothetical events, assess the expected cost of natural hazards for a portfolio, and estimate the probability of exceeding some loss level. The financial effects of deductibles or reinsurance can be measured (Boissonade and Dong, 1993). An Applied Insurance Research study of hurricanes gave \$53 billion for a class 5 hurricane hitting Miami and \$52 billion for a class 4 hitting New York (IRC, 1995). The expected severity of the hazard often is codified by zoning territory to control the amount of risk in any event (Nierhaus, 1986). The CRESTA (Catastrophe Risk Evaluating and Standardized Target Accumulations) system for earthquakes was invented by reinsurers (Foreman, 1989). A multi-peril approach for Australia uses 52 zones for cyclone, thunderstorm, wildfire, and earthquake (Flitcroft, 1989).

17.3.3. *Socioeconomic Factors*

World population is increasingly concentrated in urban areas, coastal regions, and river valleys (Marco and Cayuela, 1992). The concentration of property in such areas exposes insurers to potentially large losses from extreme events. Already, two-thirds of the world population live within 60 km of the coast; this is expected to rise to 75% by 2010 (IPCC, 1994). The total amount of property assets is not well recorded. Hohmeyer and Gartner (1992) updated a 1971 estimate to give \$22 trillion, but, allowing for economic growth, this must be at least \$50 trillion by now. In 1988, insured property values were \$2 trillion on the Gulf and Atlantic coasts of the United States (IRC, 1995). Most of the insured cost of storms relates to domestic property. This is explained by the sector's greater size and the greater likelihood that industry and government will self-insure their risks from weather. Prosperity has resulted in an increasing stock of personal property, often vulnerable to water, salt, and smoke damage. Parallel changes have occurred in commercial/industrial properties. Changes in organization and practice, and the increased significance of services like tourism, make interruption to business from extreme events more important. See Chapters 11 and 12 for more detail.

Whenever a major flood or storm occurs and householders are uninsured, political pressures build up. Regulators are faced with irreconcilable duties: to make insurance affordable but also available. If premium levels are held down, an influx of

claims from high-hazard policies may make the insurer insolvent (Denlea, 1994). A similar dichotomy is evident in the taxation treatment of catastrophe-prone business. The noncatastrophe years are milked for tax revenue, as opposed to allowing the transfer of “profits” to capital reserves (ABI, 1993). In recent years, media attention has highlighted insurance issues (Winters, 1993). Insurers therefore have been forced to settle claims with a minimum of investigation. Independent research shows that many claims are now either exaggerated or totally false (Shearn, 1994).

17.4. Extreme Events and Property Insurance

Severe events are the source of the greatest damage (Olsthoorn and Tol, 1993). For example, floods with a return period greater than 100 years cause more than 50% of the property damage arising from all floods (Smith, 1991). The following climate extremes are of concern to the industry:

River basin and coastal floods: What constitutes a serious flood is in part culture-dependent (Gardiner, 1992). Marco (1992) states that 0.3 m is a “small disturbance,” with 1 m causing “a major disaster.” The speed of water movement is also important (Smith, 1991).

Drought: The impacts are direct on harvests (which may be insured, and form the basis for futures trading) and indirect through wildfire or building subsidence due to excessive extraction of groundwater (Hadfield, 1994) or drying clay soils (Freeman, 1992).

Windstorm: Maximum gust and storm duration are both important (Schraft *et al.*, 1993), as are gustiness (Muir-Wood, 1993) and the location of the storm track in relation to population centers (Swiss Re, 1994a). A critical determinant of losses is the non-linear relationship of windspeed to damage (Munich Re, 1993; Schraft *et al.*, 1993). Figure 17-1 shows this for the October 1987 storm that devastated southeast England (Dlugolecki, 1992). Because there is a limit to the damage that can be suffered, the full response curve is sigmoid. Hurricanes produce much higher damage because they are more intense and often accompanied by storm surges, and standards of building control may be poor. “Rainy” storms are more costly than “dry” storms (Bryant, 1991). This may mean an increased storm cost in the future because the atmosphere will generally be more water-laden (see Chapter 6, *Climate Models—Projections of Future Climate*, in the IPCC Working Group I volume). Bryant (1991) also reports the possibility that cyclones can trigger earthquakes.

Convective events and precipitation extremes: Tornadoes, hailstorms, and thunderstorms are expensive despite their localized nature (Munich Re, 1984; Staveley, 1991). Heavy rainfall events can lead to landslides (Ahmad, 1991; Manning *et al.*, 1992).

Temperature extremes: Low temperatures can cause significant property damage due to burst pipes and subsequent escape of water. High- and low-temperature extremes can

reduce agricultural and industrial production (Palutikof, 1983) and increase mortality rates.

17.4.1. Present-Day Trends in Extremes

Lengthy base periods and a stable climate are essential to assess return periods (Knox, 1993; Tol, 1993). Reilly (1984) suggests that using 30 years’ data could underestimate the true risk by 50%. Marco (1992) notes that current data may not be adequate to assess 100-year flood levels, yet the latter is the design level used for the U.S. Flood Program (with a second, 500-year level). Return periods often are reevaluated in the light of new extremes (Wilkinson and Law, 1990; Tooley, 1992; Anderson and Black, 1993). Attempts to develop long climate time series can be beset by inhomogeneities in the underlying data (von Storch *et al.*, 1993a). The impact of what may be termed “combined events” is important for the industry. Windstorm damage will be greatly increased if there is associated heavy rain or a storm surge (Englefield *et al.*, 1990; Davis and Dolan, 1993). The need for appropriate information has led some insurers to seek solutions through in-house research (Munich Re, 1990, 1993).

There is a large literature on present-day trends in extremes, which is thoroughly reviewed in Chapter 3, *Observed Climate Variability and Change*, of the IPCC Working Group I volume.

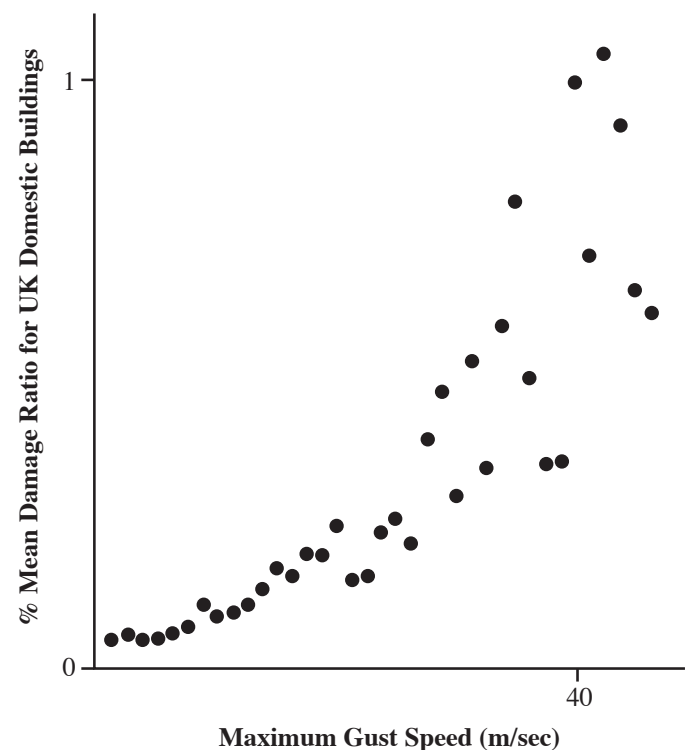


Figure 17-1: Storm cost vs. windspeed (October 1987). Mean damage ratio is based on Association of British Insurers data at postcode-district level (claims cost as a ratio of total value of insured property) for domestic buildings. Windspeed is interpolated from maps in Buller (1988). Each observation represents a postcode sector.

Just as climate varies regionally, we must expect any trends toward changes, or variability, in climate also to vary regionally (Jones and Briffa, 1992). One of the best-studied areas is North Atlantic storms. A study of the literature indicates some of the problems in attempting to determine whether trends are present. Lamb (1991) and Diaz *et al.* (1992) compiled long series of storm and wind records, respectively, but inhomogeneities in data collection are obvious or have been detected (Isemer, 1992). In the absence of reliable long-term records of windspeeds, one approach is to use a proxy variable with a long homogeneous record—for example, trends in the geostrophic wind calculated from mean sea-level pressure data (Palutikof *et al.*, 1992; Schmidt and von Storch, 1993; von Storch *et al.*, 1993b). These authors failed to find any trend that could not be explained by data inhomogeneities. A related insurance study suggests no trend in UK storminess over 60 years (Christofides *et al.*, 1992), but other studies show a correlation between winter storms and temperature (Doberitz, 1991; Dlugolecki, 1992) or a tendency to deeper depressions in the Atlantic in this century (Schinke, 1992). Again, it has been suggested that this is due to inhomogeneities in compiling weather maps (Schmidt and von Storch, 1993).

17.4.2. *Appropriate Information on Future Climate Change and Extreme Events*

The recognized source of information on future climate change is the general circulation model, or GCM (for a review, see Cohen, 1990; Giorgi and Mearns, 1991). Improvements in GCMs in the near future can be expected (e.g., Roeckner *et al.*, 1992), but at present GCMs are of limited use to the financial sector, for the following reasons:

- The length of model run is generally too short for statistical analysis of extreme events. Longer model runs are becoming available (e.g., Manabe and Stouffer, 1993, 1994).
- For analysis of extreme events, model output may be required at the daily timescale. Validation of variables (e.g., daily temperature) generally demonstrates inadequacies (e.g., Palutikof *et al.*, 1995). Statistical downscaling methods offer opportunities to overcome this problem (e.g., Karl *et al.*, 1990; Winkler *et al.*, 1995; Zorita *et al.*, 1995).
- Current models cannot generate sufficient spatial detail. Higher-resolution output from nested Limited Area Models (e.g., Giorgi *et al.*, 1994) needs much more computing.
- There may be a lack of consistency in model results—for example, for tropical and mid-latitude storms (Hewitson and Crane, 1992a, 1992b; von Storch *et al.*, 1993a; von Storch, 1994).

Most literature on climate change at the regional level concentrates on changes in the mean climate and on temperature and precipitation (e.g., Grotch and MacCracken, 1991; Boer *et al.*, 1992; Palutikof *et al.*, 1992). This is of limited use—first, because it is extreme events that have the greater implications for insurance; second, because changes in variables such as

windspeed and soil moisture content may be as significant as changes in temperature and precipitation. Even if the mean of a climate variable changes and the variance remains constant, the impact on the frequency of occurrence of extreme events would be nonlinear (Mearns *et al.*, 1984; Parry and Carter, 1985; Wigley, 1985). We cannot assume that the variance will remain the same in a warmer world. Katz and Brown (1992) have shown that the frequency of extreme events is more dependent on changes in the variance than in the mean.

Tropical and mid-latitude storms: GCM results indicate conflicting trends in tropical cyclone frequency and severity. Whereas Haarsma *et al.* (1993) found an increase in the number of tropical storms, Bengtsson *et al.* (1994a, 1994b) found a decrease. Similarly, there is a lack of consensus regarding future trends in mid-latitude storms (see Gates *et al.*, 1992; Hall *et al.*, 1994; Koenig *et al.*, 1993).

Convective events and precipitation extremes: Experiments with GCMs indicate a tendency for increased convective activity in a high-CO₂ world (Hansen *et al.*, 1989; Noda and Tokioka, 1989). This implies an increase in the number of more intense rainstorms and hence in runoff (Mitchell *et al.*, 1990; Gordon *et al.*, 1992; Whetton *et al.*, 1993). An increased frequency of intense rainstorms could lead, in turn, to more landslides.

Droughts: Increases in potential evapotranspiration due to higher temperatures could increase drought potential even in regions where total rainfall increases (Whetton *et al.*, 1993). Several studies project droughtiness in populated areas (Rind *et al.*, 1990: United States; Whetton *et al.*, 1993: South Australia; Palutikof *et al.*, 1994: Mediterranean region).

Temperature extremes: GCM-based regional studies indicate that there will be an increase in high-temperature extremes (Whetton *et al.*, 1993: Australia) and a decrease in low-temperature extremes (Wilson and Mitchell, 1987: Europe).

Coastal flooding: Coastal flooding may be expected to become more common as sea level rises. However, sea level will not rise uniformly around the world (Mikolajewicz *et al.*, 1990; Gregory, 1993; Chapter 7, *Changes in Sea Level*, of the IPCC Working Group I volume). Catastrophic incursions are generally the result of a combined event, such as a high tide associated with onshore winds. In Working Group I's Chapter 7, however, authors indicate that they expect little change in tide and surge as a result of sea-level rise.

17.5. *Impact of Extreme Events on Property Insurance*

The impact of an extreme event varies depending on the type of insurance system in place and socioeconomic and technological factors. Damage often is uninsured. The most expensive claims have arisen from cyclonic storms. Generally, poorer countries suffer more from the effects of extreme events because their economies are based on primary, weather-vulnerable activities. Less than 0.1% of gross domestic product (GDP) is “burnt up” by catastrophes in United States

(Anderson, 1991), compared to 49% in Tanzania (Nanjira, 1991). Damage to infrastructure may significantly delay recovery (Marco and Cayuela, 1992). Repair costs are often surprisingly high, since the owners may not be in residence; building materials may be in short supply, giving rise to sharp inflationary rises in repair costs; and stricter standards may be enforced (Insurance Services Office, 1994). Increasingly, claims arise indirectly from the disruption caused (business interruption) as well as the direct property damage. Much equipment is vulnerable to water, salt, or smoke damage, and often stocks of goods are minimal, so production quickly ceases (Berz, 1988; Horichi, 1993). Services such as tourism are also prone to interruption from denial of access or from consumer anxiety.

Reinsurers have noted a fourfold increase in disasters since the 1960s (Berz and Conrad, 1993). This is not due merely to better recording, because the major disasters—which account for 90% of the losses and would always be recorded—have increased just as quickly (Swiss Re, 1994a). Much of the rise is due to socioeconomic factors, but many insurers feel that the frequency of extreme events also has increased (Mercantile and General Re, 1992; Berz and Conrad, 1993). At present, the cost of insured catastrophes amounts to about 2.5% of global non-life insurance premiums (Jakobi, 1994), but in Australia it reaches 12%, without allowing for associated administration (Brigstock and Minty, 1993). The UK used to be considered relatively hazard-free. Since 1987, the cost of a single day's storm has twice exceeded £1 billion. Subsidence losses exceeded £500 million in 1990 and 1991, from a base of under £100 million in previous years (Dlugolecki *et al.*, 1995).

17.5.1. International Reinsurers and Storms

Coverage against windstorm is provided in most countries. They cause several types of harm to socioeconomic systems—property damage, lost production, macroeconomic disruption, and personal death, injury, or stress (Anderson, 1991; Smith, 1991). Table 17-1 contains information on the impact of major windstorms worldwide since 1960. To allow a valid comparison for the partial decade of the 1990s, the figures have been expressed as an annual rate in constant values. There is a very clear upward trend in the number and overall cost. In addition,

Table 17-1: Major windstorms^a worldwide: Annual impact 1960–1992.

	1960s	1970s	1980s	1990s
Number	0.8	1.3	2.9	5.0
Total Damage (\$B)	2.0	2.9	3.4	20.2
Insured Cost (\$B)	0.5	0.8	1.7	11.3

Notes: Valued at 1990 prices; data from Munich Re & Swiss Re; 1990s include only 1990, 1991, and 1992.

^a A major windstorm is defined as one costing more than \$500M in total damage.

Table 17-2: “Billion dollar” storms.

Year	Event	Insured Cost (\$B)
1987	“Hurricane” in SE England/NW France	2.5
1988	Hurricane Gilbert in Jamaica/Mexico	0.8
1989	Hurricane Hugo in Puerto Rico/S. Carolina	5.8
1990	European Storms—Four	10.4
1991	Typhoon Mireille in Japan	4.8
1992	Hurricane Andrew in Florida	16.5
1993	“Storm of the Century” in Eastern USA	1.7
1995	Hailstorms in Texas	1.1
1995	Hurricane Opal in Southern USA	2.1

Sources: Munich Re, 1990; Leggett, 1994; PCS, 1995.

the proportion of insured damage has risen to more than 50% in the 1990s.

Table 17-2 shows insurers had at least one “billion dollar” storm event every year from 1987 to 1993. With such an unexpectedly high frequency, some local insurance companies collapsed, and the international reinsurance market went into shock. These catastrophe losses were one of the reasons for the crisis at Lloyd's, where capacity for all types of insurance fell from £11.4 billion to £8.9 billion between 1991 and 1993 (Tillinghast, 1994). Following the initial reduction in reinsurance availability, there has been recovery as new capital takes advantage of the consequent rise in premium rates, often in offshore tax havens (Hindle, 1993). However, this only has happened by trebling the insurer's retention and increasing the reinsurance charge by a factor of four or five (Laderman, 1993). Reinsurance contracts now have far more restrictive conditions (Powers and Hearn, 1993; Jakobi, 1994). Some hazard-prone regions such as the Caribbean and Pacific now find insurance very expensive or even impossible to obtain (Murray, 1993).

17.5.2. Operational Repercussions

The financial insurance market itself may be disrupted by the effects of storm or flood because of serious failures of power and communications. Companies are tending to focus operations at fewer sites; if any single site is affected, the total impact will be greater. Insurers and loss adjusters may find the increased volume of claims difficult to handle because they probably will be operating on much tighter margins, with fewer staff in reserve (Dlugolecki *et al.*, 1994).

17.5.3. Criticality of Events

Given that it is never possible to guarantee security even with a known loss distribution, the pressure of a worsening loss distribution has serious consequences (Brigstock and Minty, 1993). In such circumstances, the large thrive and the small

Box 17-2. Jamaica and Hurricane Gilbert

On 12 September 1988, Hurricane Gilbert struck Jamaica with winds of 220 kph but no real storm surge. Total losses were about \$1 billion, equivalent to about one-third of the annual gross national product (GNP). More than 40% of the housing stock was destroyed, with heavy losses in agriculture, industry, and public services (Siegel and Witham, 1991). Indirect losses were estimated to be up to twice the direct damage, owing to lost production and reduced tourism. The recovery process was hampered by lack of records (Siegel and Witham, 1991), damage to public infrastructure (Alexander, 1993), and scarcity of many goods. Clement (1990) noted that the damage was exacerbated by poor construction practice and breakdown of public order.

The financial consequences were serious. Inflation doubled, and the trade deficit widened from 7% to 39% of GDP (Commonwealth Secretariat, 1991). The currency was devalued (Clement, 1990). Insurance records indicate that 8% of the insured values were destroyed—by no means extreme compared to the 30% caused by Hurricane Iniki in the Pacific (Murray, 1993) but far more extreme than European values. There was a painful readjustment in premium levels, contract terms, and risk-management requirements (Murray, 1993; Saunders, 1993; Nesbeth, 1994), but only when Hurricane Hugo emphasized the loss potential. Jamaica, like the entire Hurricane Belt, had been fortunate for many years; the average recurrence since 1881 for hurricanes had been 5.1 years (Siegel and Witham, 1991).

The Commonwealth Secretariat (1991) noted the benefits of insurance to industry: 90% of plant and 75% of stock was insured. Owing to the heavy use of international reinsurance, only 2% of the insured damage was paid by the local market. This event is typical of the threat to economic development from cyclones (Granger, 1989). Even in Mexico it took twenty months to repair structural damage, with serious consequences for tourism (Clark, 1991b).

survive: The proportion of the U.S. reinsurance market held by the top ten companies rose from 44% in 1985 to 57% in 1992. Clearly, each country will have its own “critical event.” At one time it was thought that two hurricane “hits” of \$7 billion in one season would be critical to the insurance industry (AIRAC, 1986). However, the industry coped with Hurricane Andrew (\$16 billion insured damage, \$30 billion in total), although seven companies became insolvent and forty-four sought to reduce their exposure afterward (Insurance Services Office, 1994). Exercises to assess the impact of a major earthquake on the U.S. insurance industry provide some feel for the impact of a major hurricane. Doherty (1993) felt that a \$50 billion event would seriously weaken the U.S. insurance industry with its capital base of about \$160 billion and leave property owners less well-protected financially. A second study found that the system should be able to cope with an event up to \$100 billion because of the immense size of the American economy (GDP in 1990 was \$5.5 trillion) (Cochrane, 1993). This study assumed that new capital would enter the industry. It neglected the problems of regional blight and nonavailability of insurance, which would certainly follow. Potentially, as insurers liquidate investments to raise cash, there would be some impact on financial markets, despite reconstruction (Hofmann, 1990).

The global insurance system, of course, will be able to cope with a larger event. However, the global reinsurance industry is much smaller than the direct insurance industry and can only survive by carefully controlling its exposure to any one event or territory. This makes it likely that government would be required to back any scheme for truly catastrophic losses (Gallardo, 1984; Nutter, 1994). However, Cochrane (1993) disagrees, saying that public borrowing is now at its limit and that the emphasis should be on loss prevention. It seems most

likely that multiple events would be the cause of a global failure, since the industry has proven fairly robust in response to single catastrophes. Flohn (1981) notes such occurrences in historic times, particularly when climatic change is occurring.

17.6. Adaptation to Climate Change by Property Insurers

Traditionally, insurers have dealt with changes in risk in four ways: restricting coverage so that the balance of risk-sharing shifts toward the insured; transferring risk; physical risk management (before and after the event); or raising premiums. However, in view of the increasing costs of weather claims, insurers now are considering a more fundamental approach—involving better ways of creating the funds required for irregular disasters, education of the affected parties, and cooperation with other functional or regulatory bodies in the property “system” (Horichi, 1993; Paish, 1993; Berz, 1994). Lack of information about extreme events hampers such activity and makes insurers wary of committing their capital.

17.6.1. Restricted Insurance Coverage

Increasing the contribution from the insured encourages better risk management, with consequent administrative savings. This may overcome any “moral hazard” through being insured or defended (Grose, 1992). The drawback could be in fraudulently inflated claims and a potential reduction in the fund from which to meet other claims, should the rating levels be significantly lowered. The obvious method would be to impose significant deductibles (Munich Re, 1993). Alternatives would be the increased use of coinsurance, whereby policyholders share

each loss on a predetermined percentage, and reduced upper limits of liability. “Reinstatement as new” coverage needs to be questioned because settlement net of depreciation would more fairly distribute the losses; most consumers must bear depreciation themselves (Shearn, 1994). High-risk items such as satellite dishes could be excluded.

Theoretical studies of risk transfer have identified several conditions that might make insurance nonviable (Berliner and Buhlman, 1986; Peele, 1988; Henri, 1991). These include: inadequate spread of risk, undue influence on the event by the policyholder, insufficient knowledge of the likely loss distribution, inability to define when a loss has occurred and quantify it, and, finally, premiums that are not affordable. The most common areas of nonparticipation are flood damage and damage to growing crops. A change in perception of the risk can lead to withdrawal of participation—for example, following storms in Fiji, Jamaica, and Florida (Clement, 1990; Anderson, 1991; Murray, 1993).

If insurers collectively withdrew coverage entirely for some peril, this would affect financiers, occupiers, the construction industry, and local and national government. New enterprises might never start without being able to protect their capital through insurance. Recovery following a disaster also would be problematic without the influx of insurance funds (IRC, 1995). The authorities might react as happened in Hawaii and Florida in 1993 (Insurance Services Office, 1994) to enforce participation by insurers. Insurers might still participate in the administration of a funding scheme, without bearing the risk (e.g., NFIP in the United States).

Government may decide to become directly involved in important areas such as flood or agricultural insurance where commercial insurers are unwilling (Hueth and Furtan, 1994; Ericksen, 1995). In Bangladesh, farmers require income replacement and recapitalizing, and moneylenders charge high interest rates (Hodgson and Whaites, 1993). Government can

also assist with grants and subsidies, and so forth (Foster, 1984). This has several advantages: greater financial strength, less requirement for supervision, mandatory powers to enforce compliance, and recognition of social and international issues such as income distribution and inward investment. There also can be significant disadvantages. Few countries can bear the cost of disaster alone (Mead, 1993). Many losses (e.g., tourism in East Africa; Nanjira, 1991) would not be eligible. Funds may be diverted from more desirable policies. It may encourage hazardous activities, be cumbersome to administer, and undermine the system for standard risks (Porter, 1994). Commercial insurers can help to keep such systems efficient (Dlugolecki, 1993).

Funding can be by disaster relief. This approach is limited in scope, slow to react, undignified, and fraught with abuse. If too generous, it will act as a disincentive to insurance. The goal should be to ensure that insurance coverage is affordable for property owners. Certain propertyowners may decide they have sufficient resources to deal with the hazards themselves (e.g., government and big business) and choose not to insure on a rational basis (Geneva Association, 1992).

17.6.2. *Transfer of Risk*

Insurers have traditionally shared major exposures to loss with reinsurers. The solvency of the reinsurer is critical (Porro, 1984). Reinsurers now assess whether a given territory will be able to “pay back” its losses within, say, 10 years and carefully control their exposure (Crowley, 1991). Clearly therefore, insurers can only insure great natural perils if they are themselves financially strong, they charge an economic rate to reflect the underlying risk and the partial availability of reinsurance, and they underwrite the risks by acquiring sufficient information and adapting the contract terms to fit the degree of hazard.

A new approach is “catastrophe futures”—contracts issued quarterly at a specific price and redeemable at a price based

Box 17-3. Example of Criticality and Reinsurance

Suppose an insurer covers a portfolio of one million domestic buildings (with contents) valued in total at \$100 billion. At an average rate of 0.3%, this gives an annual total premium of \$300 million. The rating allows for a catastrophe every 10 years at a claims cost of \$100 million, or \$10 million per year. The insurer holds free reserves equal to 40% of the premium, equivalent to \$120 million. Clearly, the fund can cope with the average catastrophe cost of \$10 million per year, but it would be virtually wiped out in the year of the disaster. This is why reinsurance is necessary.

In 1987, the typical excess-of-loss reinsurance protection was equivalent to 30% of the premium at risk (Laderman, 1993). In the above example, we assume that \$90 million of the risk was transferred [remember, the risk is actually the value of the property at risk (i.e., \$100 billion)]. For this the insurer would pay a reinsurance premium somewhat higher than the annualized catastrophe cost, say \$12 million. In the year of a catastrophe, he would now suffer \$10 million catastrophe (= \$100–90 million), which his resources can accommodate. Clearly, if catastrophes become more frequent, the reinsurer suffers most. However, if catastrophes become larger, the insurer suffers because he faces all the incremental claims above the reinsurer’s cutoff point. In fact by 1993, the insurer would have raised his protection to \$200 million, but with a deductible of \$30 million. At the same time, the reinsurer would have increased his charge to perhaps \$75 million (Laderman, 1993)!

upon the actual cost of future catastrophe claims (Bannister, 1993; UNCTAD, 1994). The benefits to the risk bearers are obvious, but so far this approach has not taken off because it lacks an obvious seller to match the buyer (insurer) (Boose and Graham, 1993). Also, insurance regulators need to recognize these contracts as admissible assets (ISO, 1994).

17.6.3. Physical Risk Management

Risk management is “a discipline for living with the possibility that future events may cause harm” (Kloman, 1992). It embraces physical and monetary techniques; we deal with the latter under other headings. Traditionally it has been site-specific, but now there are national and international initiatives [e.g., International Decade for Natural Disaster Reduction (IDNDR)]. Because development has grown very rapidly, there often is no realization of the hazard potential. Also, insurance is not required by the ultimate property owner until later and is often just part of a financial deal. Effective risk management comprises understanding the hazard and eliminating it, if possible; if not, it plans how to modify the impact of an event or the property likely to be at hazard and how to mitigate the loss after the event (Foster, 1984). It involves such techniques as hazard mapping, improved design, simulations, and a full disaster plan including the warning system, emergency response, and recovery (Stone, 1992). Land-use control and information are also essential (Berz, 1994). The issue of coastal defense is considered in detail in Chapter 9.

Within the construction sector, it is essential to identify the standards required and adhere to them. Incorrect construction often is to blame for damage; indeed, one of the great future issues will be how to “retrofit” substandard buildings (Sparks, 1993). This is now done regularly in Fiji, with a scheme that features professional certification of the work and premium discounts (FBSC, 1985; Walker, 1989, 1992). Unless adequate checks and controls are maintained on reinstatement works, the reconstruction may be carried out in a shoddy way—leading to further problems for the future (Norton and Chantry, 1993). It may be necessary to rebuild to higher standards (Peele, 1988).

Storm: Most damage is roof-related or due to poor detailing or wind-blown debris (NCPI, 1992a, 1992b; FEMA, 1992b, 1993). There is always pressure to reduce building costs (Norton and Chantry, 1993). Meek and Tattersall (1989) estimate that higher building standards introduced after Cyclone Tracy in Darwin, Australia would reduce damage by a factor of five. Offshore exposures are an obvious concern. Hurricane Andrew damaged or destroyed 173 energy rigs (Leggett, 1993a).

Flood: This peril is very destructive and strongly localized (Cuny, 1991; Moser, 1992). Yevjevich (1992) lists thirty-three methods to cope with flood—divided into insurance, intensive physical and extensive physical flood-proofing, prediction, and prevention. Alternative accommodation is often required. More stringent planning controls on floodplain development must be adopted (Henri, 1991). Appropriate defense work must be given

Box 17-4. Risk Management in Tanzania

In recent years, Tanzania has experienced heavy rains and floods. Severe windstorms have been frequent in the lake zone. These have caused financial loss, death, injuries, and the spread of diseases. The government has issued several directives prohibiting construction in the lower lands and has allocated new sites on higher ground. Most of the people cannot afford insurance. The lake zone is the main cotton-growing area. Natural-perils damage to the stored crop and the silos in which they are stored can be covered. The Cotton Act strictly regulates storage construction, and the National Insurance Corporation sends surveyors to advise the cooperative unions on how to minimize loss occurrences. To date, the National Insurance Corporation does not provide growing-crop insurance due to the lack of reliable data.

higher priority in the known problem areas (Anderson, 1991; Shearn, 1994). Upgrading buildings during maintenance (Miller, 1989), reviewing drainage capacity (Robbins, 1993), and landscaping exposed sites (Bush, 1994) could be very effective.

Risk management involves issues that go beyond the purview of the insurance industry. However, insurers and reinsurers play a leading role in mapping hazards, promoting better design codes, and improving the quality of implementation through trade bodies like the Insurance Institute for Property Loss Reduction (IIPLR) in the United States. At the micro-level, insurers inspect many buildings, making insurance dependent on adopting the inspector's recommendations for risk mitigation. Loss control is generally efficient, with help lines, recommended tradesmen, the use of loss adjusters in emergency panels, instructions through the media, and specialist recovery agencies. However, with the wholesale reduction of staffing in the financial sector, future response may be less effective. It is important that insurers reflect varying degrees of protection in their premium levels, to encourage risk management (Foster, 1984; Natsios, 1991). Infrastructure work such as sea defenses should fall to the public purse. Much of the benefit might accrue to non-property owners, and many property owners do not purchase insurance.

17.6.4. Technical Pricing

The initial response to increased losses might be to increase premiums. However, the decision is not usually simple because the market is increasingly competitive. The buying of market share inevitably leads to adverse results (the “underwriting cycle”) (Munkhammar and Themptander, 1984). Individual property rating is based on value at risk, with an assessment of such factors as location, construction, and, for large commercial risks, trade processes. The rate is derived from past losses and modified for irregular events, administration expenses, and

profit margin (Brigstock and Minty, 1993). This method is clearly flawed if the size and number of weather related incidents are rising. Reinsurance pricing can modify the direct insurer's strategy significantly (Laderman, 1993). Recent experience will strongly color the consumer's expectations and willingness to pay (Changnon and Changnon, 1990). Owners tend to understate property values, which makes it difficult to ensure that an adequate fund is built up and also makes restitution contentious.

The general principle of insurance is to "share the risk." Henri (1993) points out that using a rate that does not reflect the degree of hazard will result in economically inefficient behavior (adverse selection). Below-average risks will be reluctant to insure, while insurers will shy away from the increasingly heavy pool of risks. A rate varying to reflect the individual exposure to hazard encourages risk management but can result in standard insurance becoming too expensive for some. It is desirable for insurance to be a prerequisite of property purchase/ownership; otherwise damage may not be repaired, leading to a downward spiral of decay. It is easier to achieve tradeoffs with a multi-peril policy (Anderson, 1976), and it has practical benefits in claim handling.

17.6.5. Funding over Time

Retrofunding is sometimes used commercially, similar to a banker's line of credit (Jakobi, 1994), but generally it is a government tool, taking the form of relief payments. These payments often do not provide sufficient or efficient assistance (Anderson, 1991; Kunreuther, 1984). The alternative of pre-funding (insurance) is therefore coming to the fore. It is important that natural-hazard insurance be treated as a long-term business rather than being accounted and taxed annually. The premiums must provide sufficient surplus to give a reserve for disasters through the troughs of the underwriting cycle. Catastrophe reserves should be accumulated over years, to reduce reliance upon reinsurance arrangements or shareholders' funds and to allow the accumulation of investment gains (Porro, 1984). The build-up of such reserve funds often is exempt from taxation (ABI, 1993; Candel, 1993). Insurers will still require reinsurance to cope with "super-catastrophes" or "multiple hits."

17.6.6. Improving the Knowledge Base

The collection and dissemination of information—including education and vocational training—is critical to the success of risk management (Foster, 1984; Ward, 1991). However, there is a serious lack of knowledge everywhere on weather patterns; the effects of climate change on these patterns; the effects of these changes on the potential for property loss and associated consequential costs to society and individuals; the value and specific locations and types of property at risk; and, lastly, a detailed record of the actual losses sustained (insured and uninsured). Insurers will not underwrite climate risks

without adequate information on their variability and magnitude. Almost all countries have some form of natural-hazards risk analysis in hand, often prompted by UN initiatives such as IDNDR. Probably the only viable way is to rely on each country to carry out the work for its own hazards but to use common standards—and with central funding for less-developed nations, possibly using the IDNDR as a body to coordinate databases, not just for commercial needs but for the public good (McCulloch and Etkin, 1995). The basic climate data are increasingly costly but are essential both for projecting models of future trends and for claims verification.

17.6.7. Cooperation

Instead of dealing with problems piecemeal, financial industries need to influence the decisions of a wide variety of bodies and policymakers at the strategic level:

- The construction industry: regarding methods, standards, and regulation of construction
- Government and its various departments:
 - To resist new development in high risk areas
 - To protect existing developments in high risk areas
 - To plan how insurance can help society cope with extreme events.
- International bodies (e.g., United Nations): Many issues now are transnational (e.g., pollution, competition, communication, climate change). The insurance industry has no international underwriting organization, and this now seems an important gap. Such a body also could coordinate the industry's research work.

17.7. Impacts and Adaptation in Other Financial Services

The bulk of this chapter has dealt with the effects of weather and climate change on the insurance of property. However, other financial services may be affected. Many of the processes involved are similar to property insurance underwriting in that risks are assessed before a financial commitment is made.

17.7.1. Likely Impacts in Other Non-Life Insurance Activities

Transportation: This sector is an integral part of modern society. In addition to providing the means for our lifestyles and economies to function, transport goods and services are products in themselves, and the organizations supplying them are major employers. Sensitivity to weather and climate change is considered fully in Chapter 11. Extreme conditions can be very disruptive, causing damage and delay, often compounded by human error in these conditions. There has not been a major published study in this respect. Damage to infrastructure is generally not insured. Damage and particularly injury caused to other users is often insured. Hail damage to vehicles was a particular concern in the Munich hailstorm of 1984 (Munich Re, 1984). However, compensation for delays is not

generally covered because of the practical difficulties in proving losses. Travel insurance is an exception, but the sums insured are small.

Liability insurance: Liability insurance has become a rather difficult sector, with the over-use of tort law and increasing emphasis on strict liability combined with environmental degradation claims (Winters, 1993; Nutter, 1994). In dealing with impacts of weather, it is often difficult to prove negligence or to identify a currently pursuable person or organization. There has been some litigation in this field—for example, control of tree-root invasion into neighboring buildings (Institution of Structural Engineers, 1994); control of undergrowth following bush fires in Australia costing over \$100 million (Alexander, 1993); limitation of beach erosion, which is often initiated by human action (Bryant, 1991); and even the accuracy of weather forecasts and flood control (Kusler, 1985). At a strategic level, there has even been discussion of national liability for climate change (Stone, 1992; Leggett, 1994), but this does not seem likely to become a commercially insurable risk. An interesting case cited by Changnon and Changnon (1990) involved liability for overselling drought policies, resulting in underwriting losses of \$8 million.

Crop insurance: Agriculture is a key sector in many nations, though often it is not a part of the market economy. In most countries, insurers do not offer coverage for growing crops because of the possibility of catastrophic loss and the difficulties of loss control and evaluation. However, schemes do exist. Durham (1994) describes the use of crop insurance in the United States, where a multi-peril-crop insurance policy is sponsored by the federal government, with varying participation by private insurers. Hueth and Furtan (1994) coordinated a detailed investigation of such schemes in the United States, Canada, and other developed economies. They came to the conclusion that crop insurance was not the best way to address farmers' yield uncertainty because of moral hazard (the temptation not to mitigate losses because they will be met by insurance) and adverse selection (the tendency for farmers with worse-than-average risks to insure, knowing that they will make a "profit," while the better risks will not insure). The situation is further complicated by the relatively liberal granting of disaster relief in times of hardship, which discourages the prudent farmer from buying insurance at all. Sugar-crop insurance in Mauritius has been compulsory since 1946 and is government-administered. The scheme was discussed for Tanzania but not adopted (Putty, 1984). Similar schemes exist elsewhere (e.g., Costa Rica), with support from the banking sector (Gallardo, 1984). Climate change is expected to have significant impacts on agriculture (see Chapter 13), so it may be expected that interest in this area will increase.

The various considerations in Section 17.6 apply here. In transportation, weather-related hazards are likely to remain subordinate. There will be more attention to risk management in specific circumstances (e.g., tree owners, coastal property owners) to minimize liability. With regard to crops, private insurers are unlikely to take on large commitments.

17.7.2. Life Insurance and Pensions

By contrast with general insurance, these industries are long-term, highly actuarial in nature, and often linked with savings plans. The contracts are underwritten less rigorously than many general policies, are unusually nonrenewable, and last for many years, until terminated by death of the insured. Investment of the premiums is a major activity, with the emphasis on security over many years. A range of instruments is used, from government bonds to corporate stock, real estate, and fine art. The industry generated \$770 billion in premiums in 1992 and is highly influenced by changes in government policy on social insurance and fiscal matters (Swiss Re, 1994b). As with general business, about 85% of the market lies in the United States, EU, and Japan. Although the volume of business is comparable to general insurance, the investible funds are much greater (\$3,075 billion in 1989, as against \$832 billion for non-life business).

Likely Impacts: The impact of climate change is likely to come in two ways. The first is through changes in morbidity or mortality. Such changes are associated with extremes of heat and cold. Potentially, shifts in mean conditions could lead to the introduction of new pests and diseases or, occasionally, the elimination of old ones (Epstein and Sharp, 1994). There have been many weather-related deaths in developing countries but, in general, without any significant involvement of life insurers. Indirect effects might include food and water shortages (see Chapter 18). The second major impact is in the potential impact on investments. Long-term decisions really need to include climate change as a factor, but this is definitely not happening yet. This will be discussed more fully in Section 17.7.3.

Adaptation: Given that there are many other imponderables such as drugs or crime-related influences on human well-being, it is unlikely that meaningful adjustments to mortality tables can be made. However, investment strategy can be adapted over a shorter period and therefore should be updated periodically to recognize the current views on the impact of climate change (Porro, 1984).

17.7.3. Banking

The other major industry is "banking," which also covers a wide range of activities. Liquid assets (e.g., savings and profits) are invested, either short term to finance debt (e.g., overdrafts) or long-term to finance assets (e.g., mortgages) and provide pensions. This requires banks to provide treasury and investment-management services. Some investments are speculative, with an uncertain return, but often loans are provided in return for fixed interest. This requires similar skills to insurance underwriting, in order to assess the riskiness of the venture or the likelihood of repayment. Loans often are secured on assets such as property (which is itself insured against damage) in order to provide some guarantee of repayment. The majority of loans are short-term (less than five years). Finally, the sector may act to organize the raising of capital for a project or to

strengthen the capital base of a company by finding new shareholders. A large and increasing range of financial instruments is used to manage the inherent financial risks (hedging, etc.) (Thompson, 1995).

In relation to this topic, banks fall into three types: international banks (i.e., economically involved all over the world); regional banks; and specialist banks, including building societies, “thrifts,” and similar institutions. There has been much talk of product integration between banks and insurers (still forbidden in some countries). However, the cultural differences in treating claims versus bad debts, for example, make this unlikely for the mass consumer market. At corporate level, “risk” and “finance” are almost interchangeable (Seebauer, 1992).

17.7.3.1. Likely Impacts

Banking will be affected indirectly as its customers find their operations, consumption, and/or financial circumstances affected by climate change. Specifically, the banking industry and any investment activity could be affected if property insurers withdraw coverage from property that was the subject for some long-term financial transaction. This already has happened in some small island states, and any coastal site must be challengable (Leggett, 1993a; Dlugolecki *et al.*, 1995). Indeed, the burden of uninsured catastrophe losses could cause loan defaults (Vaughan, 1994). Sectors that may be adversely affected, such as tourism and agriculture in certain regions, may find it difficult to raise finance if uninsured losses are perceived to be a real threat to viability. Moreover, a fall in property values precipitated by a loss of confidence in the local economy could itself trigger a “credit famine,” because property is often used as security for loans (Medioli, 1989; Bender, 1991; Thompson, 1995).

If a financial center is unexpectedly exposed to extreme weather events, the added effect associated with being disrupted or even cut off from the nonstop global financial markets could be significant.

It can be argued that for the world banking system there is no critical threshold of climate change because banks would cooperate to reestablish a new basis, as happened after the Third-World debt crisis. The huge scale of global financial flows would outweigh the likely cost of even a series of catastrophes (Dlugolecki and Klein, 1994). At the national level, the banking system could be reestablished with external assistance, but of course this would result in a permanent weakening of the local economy though adjustments in the exchange rate and interest rates. As with insurance, the scale of event will vary from one country to another. For Jamaica, Hurricane Gilbert was extreme enough to cause lasting financial damage (Commonwealth Secretariat, 1991). Cochrane (1993) reports that the U.S. banking system has withstood two shocks of around \$300 billion due to rapid changes in oil prices. He concludes that the effect of \$100 billion natural catastrophe (in this case, earthquake) could be absorbed. While this might be true

at the scale of the U.S. economy, there is no doubt that major local disruption would result, with failures at the micro-level.

Investment activities can be affected indirectly by climate change through the actions of other sectors. In particular, mitigation policies to alter the production and use of energy may have a strong effect on the transport and energy sectors. This may alter the economics of specific technologies and entire nations or regions, with implications for rates of return on investment. Without coherent early guidance, changes in policy may result in suboptimal investment decisions. A more subtle effect on banking may stem from the changing mix of consumption and business activities brought about by climate change (Vaughan, 1994). This will surely affect the requirements for financial services, but no study has been made of this yet.

17.7.3.2. Adaptation

In banking, the key issues will be to anticipate the growing risk exposure of lenders by reduced insurance coverage, to include climate change as one of the factors in assessing the risk in investment and lending opportunities (past and future), to plan for changes in client portfolio, caused by global warming, and to anticipate operational impacts of climate change as outlined in Section 17.5.2.

It will be important to ensure that insurance coverage is available throughout the lifetime of loans. This will mean more stringent lending conditions. Environmentally integrated assessment, with regard to the direct impact on assets and the indirect effect on the borrower's business, will be required. Closer cooperation with insurers, to the extent of partnership or even ownership, is a possibility. Alternatively, it may require government intervention to ensure that alternative protection is available (Britton, 1989; Kunreuther, 1993).

It should be evident that some activities or projects are more likely to be affected by climate change than others. Therefore, this should be taken into account when appraising any investment. In particular, assets with long life spans situated in coastal zones or river basins may be sensitive, and there may be certain stages of construction that are more vulnerable (Anderson, 1991; Bender, 1991). The classic banking solutions to increased risk are similar to those of property insurers: restricted involvement (with consequent difficulties for economic activity) and higher prices, including an environmental risk premium—often not easy to achieve in a competitive environment. More radical approaches are necessary for a fundamental issue like climate change, and enlightened bankers are already exploring such avenues in the light of sustainable development initiatives (Vaughan, 1994). This will initially require a substantial effort to understand the problems and may generate new services to assist those clients most affected, once they have been identified through improved screening. A suitable starting place for such studies will be comprehensive national and international assessments of climate change impact, which allow an integrated appraisal of the many activities supported by financial services

(e.g., IPCC, 1990; CCIRG, 1991). Outsiders will be keen to see how the financial sector deploys its funds in the light of climate change. Shareholders and employees will be concerned about “their” capital and how it may be affected by mitigation policies or whether it is being used “responsibly” (ACBE, 1994).

17.7.4. *Brokering*

“Brokering,” or arbitrage, provides the link between buyers and sellers of financial instruments, including foreign currency. As financial markets have become more turbulent, the use of “hedging” instruments has increased. This has been accelerated by the trend toward global markets with more deregulation (Swiss Re, 1992).

Likely impacts: A really major catastrophe could affect stock market valuations and the propensity to save. Such impacts currently are largely confined to the impact on insurers’ share values and the construction sector.

Adaptation: The role of financial markets is to reallocate risk and to process and disseminate information, and this will be even more necessary with climate change. Research into areas of uncertainty and policymaking will be important to improve the efficiency of resource allocation. Financial rating agencies will devote more attention to this aspect, in particular seeking to quantify company performance on “green” issues (Mueller *et al.*, 1994).

17.8. *Implications for Policymakers*

One of government’s roles is to provide leadership in the management of natural hazards (Towfighi, 1991; Britton and Oliver, 1993). This entails research into occurrence and impacts, followed by implementation of preventative measures. Key hazards are drought, flood, and storm, which often are not insured. Key vulnerable areas are developing countries (Stone, 1992), small island states and coastal zones (IPCC, 1990), cities (Cohen, 1991), and agriculture (IPCC, 1990). The public infrastructure is vital to recovery, but it is often exposed to natural hazards and may require retrofitting for robustness (Kreimer and Munasinghe, 1991; Minnery and Smith, 1995). Much of the cost of climate change will not be insurable [e.g., damage to ecosystems, gradual degradation, loss of economic value of coastal property (Stone, 1992)].

National planning: Short- and long-term objectives are required. Short-term objectives are principally in the area of “good housekeeping” and tightening of existing arrangements to minimize the effects of damage from extreme events. Long-term planning should consider particularly the risk of major inundation (Beatley, 1994). This is an increasing risk as population and investment move to coastal areas or river plains and will be compounded by sea-level rise. The question of how to treat property built on land to be redesignated as hazardous will be contentious (Minnery and Smith, 1995).

Education: All parties in the property market must be fully aware of the potential effects of climate change and fully educated in the means available to combat these impacts so that disaster plans can be prepared at all levels. These parties include property owners and occupiers, architects and builders, insurers, and regulatory authorities.

Integrating financial mechanisms: If the probability of an event is very low, consumers act as if it will never happen, even if the probable maximum loss is very high. It will therefore be necessary to offer incentives (or disincentives) to promote sound risk management by consumers and to introduce mandatory policies for risk-prone locations, backed by appropriate resources for regulation. In many cases, affordability will be an issue.

With better information, it will be possible to assess the risk exposure of individual entities and the nation as a whole. This will serve as a basis for discussion about which risks can be borne by the private sector. Where the risk is too hazardous for private insurance companies, there still are many advantages in involving the private insurance sector in planning for disaster mitigation. Their practical knowledge of marketing a financial product, tariff structures, access to international resources, damage recovery, avoidance of duplicate administration, and fraud control would prove invaluable (Leggett, 1993b; Vellinga and Tol, 1994). Similarly, because of the large-scale financial implications of adaptation or mitigation strategies, it will be important to consider whether and how the financial sector can contribute.

New cooperative institutions are required to draw together the many disciplines needed to tackle the implications of global warming (Kunreuther, 1994; Natsios, 1991; Sykes, 1991). The United Nations’ IDNDR and Coastal Zone Management (CZM) provide excellent platforms to begin consultation on information and mitigation strategies (Bender, 1991; Berz, 1994; Clark, 1991a). Even cautious observers support the principle of collaboration for information-gathering in the context of the potential threat of climate change (Ausubel, 1991).

Climate data: The availability and affordability of climate data for research and commercial decisionmaking is critical.

Construction industry: The authorities must work with trade associations to improve building quality and design and consider how to “retrofit” structures if necessary.

Finally, in view of the long-term nature of much financial activity, particularly pension-funding, it would be valuable for governments to give an early indication of how they might modify policy on industries that contribute to, or counter, global warming and then act consistently so that investment can be channeled efficiently (Leggett, 1994). Initially, subsidies may be important for research and development in novel technologies.

17.9. Requirements for Future Assessments

There are several key issues for property insurance and related activities. Better information is required on the past and future location, severity, and frequency of extreme events, especially storms and precipitation. The areas most vulnerable to extreme events need to be identified. Better information is required on the damage-response curve for the various hazards. A standardized database on the cost of extreme events would be extremely useful. Improved techniques are required for applying knowledge of actual events to hypothetical situations to evaluate risks (i.e., simulation).

For other areas of financial services, better information on the likely changes in morbidity or mortality is needed, as is a clearer exposition of how policymakers are likely to seek to adapt to or mitigate climate change.

Finally, it must be said that the current assessment was hampered by the lack of a substantial literature base and lack of awareness on the part of many financial services, organizations, and individuals. Therefore, a program of attention-raising is important.

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